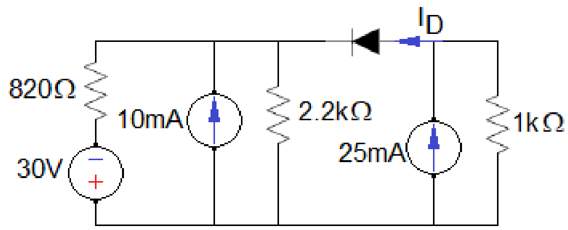
Electronics

Diodes, more circuits

Problem 1.- The following circuit is a model of a network of voltage and current sources. Use the second approximation of silicon diodes to find the current I_D.



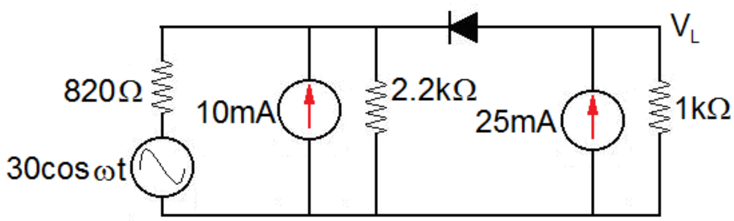
Solution: All the linear components from the point of view of the diode can be replaced by a Thevenin equivalent with the values

$$R_{Th} = 820 // 2.2k + 1k = 1.60k\Omega$$
$$V_{Th} = 25V + 15.9V = 40.9V$$

Then the current in the diode will be

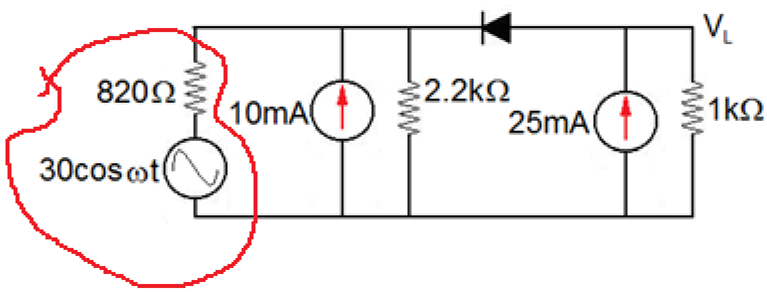
$$I_D = \frac{40.9V - 0.7V}{1.6k\Omega} = \mathbf{25.1mA}$$

Problem 2.- In the circuit shown in the figure, calculate V_L. Consider the diode as ideal in first approximation.

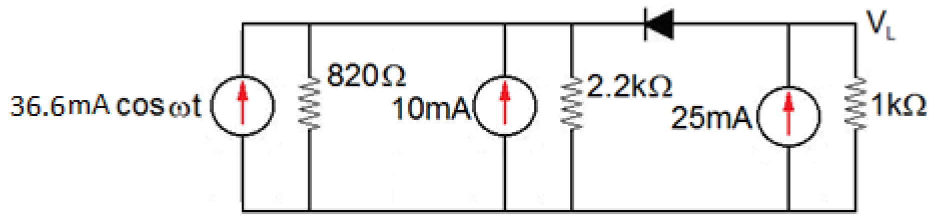


Solution: The voltage V_L can be calculated by simply multiplying the current through the 1kohm by 1kohm, but this current is the one going through the diode minus 25mA. Then, we need to find the current through the diode first.

We start by converting the voltage source on the left side of the circuit into a current source:

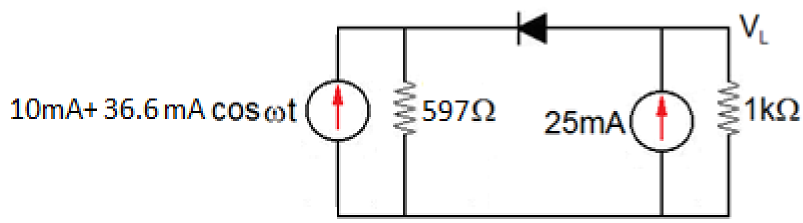


This source has the value $I_{AC} = \frac{30\cos\omega t}{820} = 36.6mA\cos\omega t$



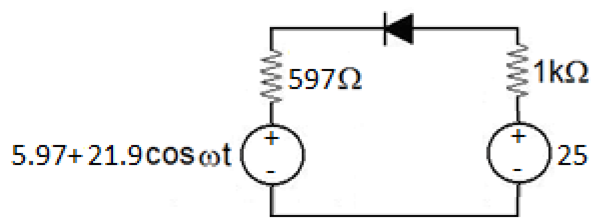
Then we simplify the network of resistances and sources to get

$820 // 2.2k = 597\Omega$

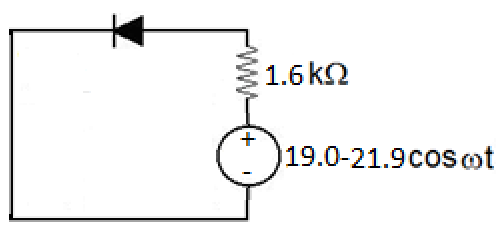


And now we convert the two current sources into voltage sources.

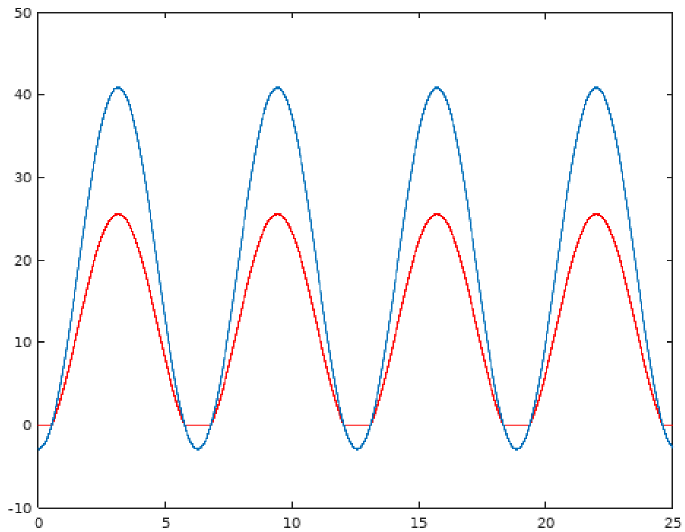
$V_1 = (10mA + 36.6mA\cos\omega t)(0.597\,kohm) = 5.97V + 21.9V\cos\omega t$
$V_2 = (25mA)(1kohm) = 25V$



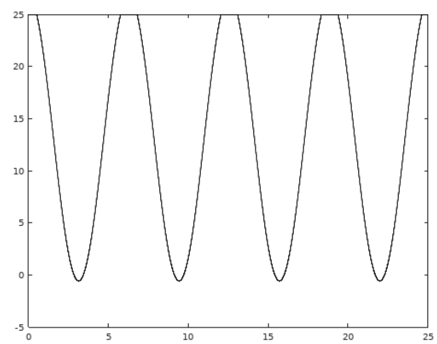
Finally we add the sources in series:



Because the diode behaves as an ideal switch in first approximation, when the voltage is positive the current will be given by V/R and zero when the voltage is negative. Below is a sketch of the source voltage (blue, V) and current through the diode (red, mA), with the horizontal scale in multiples of ωt.

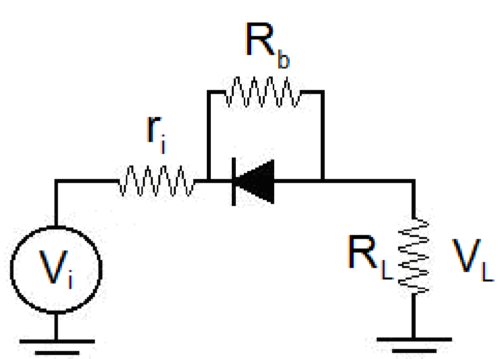


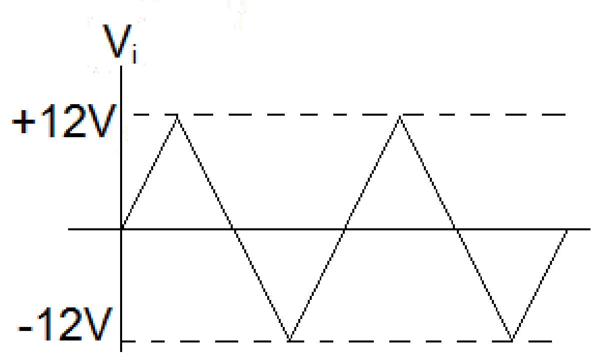
Recall that the voltage in the load is obtained by subtracting 25mA to the diode current and multiplying by 1kohm. This is the final result:



Problem 3.- The circuit shown in the figure has a non-linear response due to the silicon diode. Considering the saw-tooth input signal given Vi, sketch the output signal V_L indicating the point where the diode starts to conduct electricity and the peak values.
In your analysis consider the second approximation of the diode.

r_i=100 Ω, R_b=100 Ω, R_L=100 Ω





Solution: First, let us find when the diode starts to conduct electricity. From its point of view, the Thevenin voltage is

$$V_{Th} = V_i \frac{R_b}{R_b + r_i + R_L} = V_i \frac{100}{100+100+100} = 0.333V_i$$

The diode will conduct when this value is less than -0.7V, which means that

$$0.333V_i < -0.7 \rightarrow V_i < -2.1V$$

This point will separate the output signal in two cases:

i) If the input voltage is greater than -2.1V the diode will behave as an open circuit and the output voltage will be:

$$V_L = \frac{100}{100+100+100} V_i = 0.333V_i$$

The positive peak will be $V_L = 0.333(12) = 4V$

ii) If the input voltage is less than -2.1V, the diode will behave as a 0.7V voltage source and the output voltage will be:

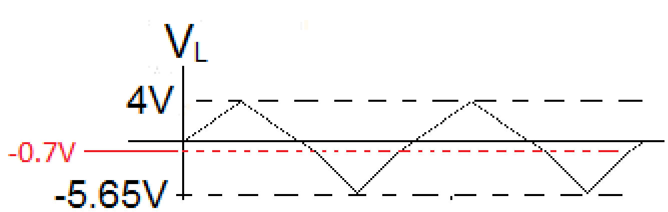
$$V_L = \frac{100}{100+100}(V_i + 0.7) = 0.5V_i + 0.35V$$

The negative peak will be $V_L = 0.5(-12) + 0.35 = -5.65V$

Notice that the transition point between cases i and ii is the same voltage, as expected:

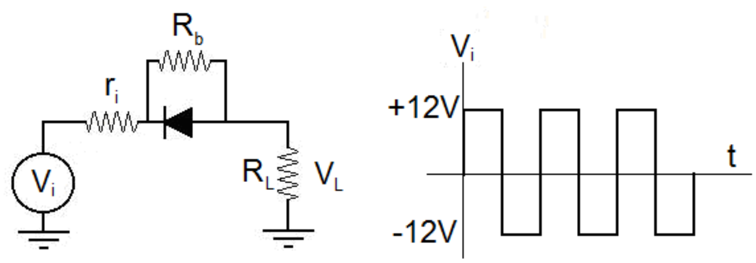
$$(i) \quad V_L(-2.1) = 0.333V_i = 0.333 \times (-2.1) = -0.7V$$
$$(ii) \quad V_L(-2.1) = 0.5V_i + 0.35V = 0.5 \times (-2.1) + 0.35 = -1.05 + 0.35 = -0.7V$$

Sketch of the output voltage:



Problem 4.- Sketch the load voltage in the circuit, given the input voltage shown in the figure. Approximate the diode as a 0.7V drop in conduction.

$r_i = 10\ \Omega$, $R_b = 33\ \Omega$, $R_L = 330\ \Omega$



Problem 5.- In the circuit shown in the figure, calculate the voltage in the load resistor.
The I-V curve of the diode can be described by the function:

$$I_D = \begin{cases} 0.02V_D^{\ 2} & V_D > 0 \\ 0 & V_D < 0 \end{cases}$$